

Renal transplantation in patients with HIV/AIDS

Eliasson, Emma Maja Sofia

Master's thesis / Diplomski rad

2015

Degree Grantor / Ustanova koja je dodijelila akademski / stručni stupanj: **University of Zagreb, School of Medicine / Sveučilište u Zagrebu, Medicinski fakultet**

Permanent link / Trajna poveznica: <https://um.nsk.hr/um:nbn:hr:105:866879>

Rights / Prava: [In copyright](#)/[Zaštićeno autorskim pravom.](#)

Download date / Datum preuzimanja: **2025-02-21**



Repository / Repozitorij:

[Dr Med - University of Zagreb School of Medicine Digital Repository](#)



**UNIVERSITY OF ZAGREB
SCHOOL OF MEDICINE**

Emma Eliasson

**Renal Transplantation in Patients with
HIV/AIDS**

GRADUATION PAPER



Zagreb, 2015

This graduation paper was made at department of Nephrology, at KBC Rebro, University of Zagreb School of Medicine under supervision of prof. dr. sc. Nikolina Bašić-Jukić and it was submitted for evaluation in the academic year 2015.

Summary

The human immunodeficiency virus (HIV)-infected patient is more prone to developing both acute and chronic renal failure than the general population. Renal disease specific to the HIV-infected population include HIV-associated nephropathy (HIVAN), mostly prevalent in the black population, and HIV immune complex kidney disease (HIVICK), which is more common in the white population. Some immune complex diseases of the kidney are thought, in the majority of cases, to originate from a co-infection with hepatitis C virus (HCV). As the life expectancy of this population is getting longer they are more likely to suffer from end organ damage due to age related diseases such as hypertension (HTN) and diabetes mellitus (DM). The kidney function can be monitored by estimated glomerular filtration rate (eGFR), albumin/creatinine ratio (ACR) and protein/creatinine ratio (PCR). Using ACR and PCR enables estimation of the renal function even in dilute urine and does not need sensitive lab machines, necessary for detecting tubular proteins in urine, that are not available at many hospitals. Treatment of established kidney disease is by managing modifiable factors, such as HTN, body weight and drug regimen as far as possible. Renal replacement therapy is indicated as for other patient groups with decreased renal function. If the patient fulfil certain criteria they are eligible for a renal transplant. Social stigma and lack of knowledge has led fewer HIV-infected patients to want transplantation. Among the HIV-specific criteria for transplantation include that the patient has to be well regulated with combined ART (cART) for at least six months and without a history of opportunistic infections. Immunosuppressive (IS) therapy was for a long time thought to enable the virus to freely replicate and hasten the progression to AIDS and death. Studies have later shown that by suppressing the immune system one is preventing activation of CD4+ T cells and, because the HIV-virus infect activated cells, they also protect new T-cells from being infected. IS may thus, on the contrary, even be beneficial in these patients. The drug interactions between IS and ART are many and complex and it is beneficial with multidisciplinary teams, including a infectologist and nephrologist, to choose the optimal therapy. Blood levels of the drugs should be checked with regular intervals to ensure therapeutic levels and prevent nephrotoxicity or rejection. The outcome after transplantation is continuing to improve. The frequency of rejection episodes is higher in this population, but the graft and patient survival is similar to the general population. Meta-analyses have concluded that renal transplantation should be offered to patients who fulfill the criteria, although the strength of evidence is very low due to small study samples.

Key words: chronic kidney disease, HIV, transplantation.

Acknowledgements

I want to thank the University of Zagreb Medical Faculty for providing me with the education that finally led to this paper. I appreciate the kind help from my mentor, Prof. Bašić-Jukić, who came with valuable pointers and profound knowledge on the matter. The kind proof reading from Eric Nham improved the style and will make this reading more pleasant to the readers. I would also like to take the opportunity to thank my family and friends who have stood by me this entire time and constantly reminding me of the joy of learning and practicing medicine.

Acronyms

→	ART	Anti-retroviral therapy
→	cART	Combined ART
→	HAART	Highly active ART
→	IS	Immunosuppressant
→	PI	Protease inhibitors
→	NNRTI	Non-nucleoside reverse transcriptase inhibitor
→	NRTI	Nucleoside reverse transcriptase inhibitor
→	EFV	Efavirenz
→	NVP	Nevirapine
→	CsA	Cyclosporine A
→	TAC	Tacrolimus
→	HTN	Hypertension
→	DM	Diabetes mellitus
→	HIV	Human immunodeficiency virus
→	HIVAN	HIV-associated nephropathy
→	RRT	Renal replacement therapy
→	ARF	Acute renal failure
→	AKI	Acute kidney injury
→	CKD	Chronic kidney disease
→	GFR	Glomerular filtration rate
→	eGFR	Estimated glomerular filtration rate
→	ESRD	End-stage renal disease
→	NSAID	Non-steroidal anti-inflammatory drug
→	ACE inhibitor	Angiotensin converting enzyme inhibitor
→	ARB	Angiotensin receptor blocker
→	HCV	Hepatitis C virus
→	HBV	Hepatitis B virus
→	PCR	Protein-Creatinine ratio
→	ACR	Albumin-Creatinine ratio
→	CG	Cockcroft-Gault
→	CKD-EPI	Chronic Kidney Disease Epidemiology Collaboration
→	MDRD	Modification of Diet in Renal Disease
→	LDKT	Living donor kidney transplantation
→	GALT	Gut associated lymphoid tissue
→	PRA	Panel reactive antibodies
→	NSTEMI	Non-ST elevation myocardial infarction
→	CNI	Calcineurin inhibitors
→	BMI	Body mass index
→	HSCT	Hematopoietic stem cell transplantation
→	HiB	Hemophilus influenza type B
→	CMV	Cytomegalovirus
→	PCP	Pneumocystis carinii pneumonia
→	NODAT	New onset of diabetes mellitus after transplantation
→	RCT	Randomized control trial
→	DGF	Delayed graft function
→	AUC	Area under the curve
→	STI	Sexually transmitted infection
→	UTI	Urinary tract infection
→	TMP-SMX	Trimethoprim-Sulfamethoxazole

Summary of drugs

Immunosuppressants

Calcineurin-inhibitors / IL-2 inhibitors

- Cyclosporine A
- Tacrolimus

Anti-metabolites

- Mycophenolate mofetil

m-TORs

- Sirolimus
- Everolimus

Anti-lymphocyte antibodies

- Thymoglobulin
- Anti-thymocyte globulin

Anti-CD25 monoclonal anti-lymphocyte antibody

- Basiliximab

Corticosteroids

- Methylprednisolone
- Prednisone

Antiretrovirals

Nucleoside reverse transcriptase (NRTIs)

- Abacavir

Non-nucleoside reverse transcriptase inhibitors (NNRTIs)

- Zidovudine
- Didanosine
- Efavirenz
- Nevirapine
- Emtricitabine
- Lamivudine
- Stavudine
- Tenofovir

Protease inhibitors (Pis)

- Indinavir
- Saquinavir
- Nelfinavir
- Ritonavir
- Fosamprenavir
- Lopinavir
- Atazanavir
- Tipranavir
- Darunavir

CCR 5 Co-receptor agonist

- Maraviroc

Fusion inhibitors

- Enfuvirtide

Integrase inhibitors

- Raltegravir
- Dolutegravir
- Elvitegravir/Cobiciclat

Co-formulated agents

- Combivir
Lamivudine/Zidovudine
- Epzicome
Abacavir/Lamivudine
- Trizivir
Abacavir/Lamivudine/Zidovudine
- Atripla
Efavirenz/Emtricitabine/Tenofovir
- Complira
Emtricitabine/Rilpivirine/Tenofovir
- Stribild
Elvitegravir/Cobicistat/Emtricitabine/
Tenofovir

Renal Transplantation in Patients with HIV/AIDS

Table of Contents

Renal Transplantation in Patients with HIV/AIDS	8
Introduction	8
History of HIV/AIDS	9
Etiology of impaired kidney function in patients with HIV/AIDS	10
Antiretroviral drug-induced nephrotoxicity	11
Non-antiretroviral drug-induced nephrotoxicity	12
Glomerular and vascular nephropathies	13
Monitoring kidney function	14
Creatinine Clearance and eGFR	16
Protein/creatinine (PCR) or albumin/creatinine ratio (ACR)	16
Renal replacement therapy (RRT)	17
Renal transplantation	18
Eligibility for the waiting list	19
The impact of immunosuppression on HIV replication	21
Outcome after transplantation	22
Infection	23
Rejection	24
Drug interactions	25
Drug selection in the transplant recipient	26
Corticosteroid-sparing regimen	28
Combined liver and kidney transplantation in the HBV/HCV-HIV infected patient	29
Discussion	30
Conclusion	31
Sources	31

Introduction

The life span of a person infected with human immunodeficiency virus (HIV) has significantly improved since its appearance in the 1980's, and is now approaching that of the general population. This has consequently led to a higher prevalence of age related diseases that also affect kidney function, such as hypertension (HTN) and diabetes mellitus (DM). Apart from those conditions there are other factors more specific to the HIV-infected

population with nephrotoxicity due to antiretroviral drugs, HIV-associated nephropathy (HIVAN) and immune complex-mediated glomerulonephritis to mention some. Although the prevalence of HIV-infected patients requiring renal replacement therapy (RRT) in Europe is fairly low, it is increasing due to the aforementioned factors. Patients infected with HIV were for a long time not considered eligible for renal transplantation due to fear that the subsequent immunosuppressive therapy would increase viral load and hasten the progression of their infection. With the introduction of highly active anti-retroviral therapy (HAART), increasing knowledge about the pathophysiology of the disease and novel immunosuppressive medication in the 1990's, transplantation results were not much worse in comparison with the HIV-negative population. One obstacle that remains still is the higher frequency of delayed graft function and acute rejection in this patient group, but constant development in knowledge and understanding of the immunosuppressive agents keep improving the outcome in this population. Renal transplantation is a treatment option that should be considered after individual evaluation of each patient with HIV and end-stage renal disease (ESRD).

History of HIV/AIDS

On June 5th 1981, the Center for Disease Control in the U.S. published a Morbidity and Mortality Weekly Report describing the finding of infections attributed to a non-functioning immune system in five apparently healthy young gay men in Los Angeles. Shortly thereafter more case series followed. In the next year, more than tens of thousands were appreciated to be infected, and the term Acquired Immune Deficiency Syndrome was coined on September 24th 1982. The definition was then “a disease at least moderately predictive of a defect in cell-mediated immunity, occurring in a person with no known cause for diminished resistance to that disease.”, but it was not until 1986 that the virus was named *Human Immunodeficiency Virus*, HIV. One year later, and six years after the first report of acquired immuno deficiency syndrome (AIDS), Food and Drug Administration (FDA) approves the first antiretroviral drug: Zidovudine. By 1994, AIDS had become the leading cause of death in all Americans in the age between 25 and 44 years. In 1995, the first Protease Inhibitor was FDA approved and we enter the era of HAART. The following year, AIDS was no longer the leading cause of death in the young and previously healthy, except in the African American population, and the world is for the first time feeling careful optimism. In 1997, 47% less patients died of AIDS or AIDS-related diseases than the previous year, which was mostly attributed to the introduction of HAART. Combination pills are starting to be produced to increase

compliance, the first *Non-Nucleoside Reverse Transcriptase*, NNRT, was approved, but resistance starts to become a problem.

As the HIV/AIDS epidemic is starting to get under control in the U.S., Canada and Europe, reports on major spread on the African continent are appearing and it is the number one killer in their whole population. The UNAIDS (the joint United Nations programme on AIDS) reports in 2002 that the average life expectancy has decreased from 62 to 47 years solely due to HIV/AIDS.¹

Etiology of impaired kidney function in patients with HIV/AIDS

Kidney disease can be classified as acute or chronic: glomerular, vascular or tubulointerstitial. HIV-infected patients may develop nephropathies due to many reasons such as a secondary cause of the virus itself, the antiretroviral therapy and/or some co-infection with e.g. hepatitis C.

Table 1. Kidney disease associated with human immunodeficiency virus (HIV) infection. Shown are diseases that are associated with HIV infection or its treatment. *Certain glomerular diseases are commonly associated with other viral infections or may occur on an idiopathic basis; a true association with HIV disease is uncertain or doubtful. Collapsing glomerulopathy is notable for glomerular, tubular and interstitial disease but is classified under glomerular disease for simplicity. According to Johnson RJ, Feehally J, Floege J (2015), p.683

Kidney Diseases Associated with HIV Infection			
	Entity	Frequency	Associations
Glomerular	Collapsing glomerulopathy	Common	African descent; particularly advanced HIV disease European, Asian descent, and black Africans in Africa
	Immune complex glomerulonephritis	Common	
	Thrombotic microangiopathy	Uncommon	Hepatitis C; enfuvirtide
	Membranoproliferative glomerulonephritis, with or without cryoglobulin-associated vasculitis	Rare*	
	Membranous nephropathy	Rare*	
	Fibrillary and immunotactoid glomerulopathies	Rare*	Nonsteroidal anti-inflammatory medication
	Amyloid nephropathy (AA type)	Rare*	
	Minimal change nephropathy	Rare*	
Tubular	Acute kidney injury	Moderately common	Aminoglycosides, cidofovir foscarnet
	Proximal tubule injury (Fanconi syndrome)	Moderately common	Tenofovir, adefovir, cidofovir, didanosine
	Diabetes insipidus	Uncommon	Amphotericin, tenofovir, didanosine, abacavir
	Chronic tubular injury	Moderately common	Amphotericin, cidofovir, adefovir, tenofovir
	Crystal nephropathy	Uncommon	Indinavir, atazanavir; sulfadiazine, ciprofloxacin, intravenous acyclovir
Interstitial	Interstitial nephritis	Uncommon	Allergy to β -lactam, sulfa, ciprofloxacin, rifampin, proton pump inhibitor, allopurinol, phenytoin; also causes of crystal nephropathy listed above BK virus; generally advanced disease Immune reconstitution inflammatory syndrome; generally advanced disease; following initiation of ART

Acute renal failure

Acute renal failure (ARF) is defined differently across studies, but a consistent feature is a drop glomerular filtration rate (GFR) with subsequent sequelae such as electrolyte derangements, encephalopathy and volume overload that may have a fatal outcome.² In a study where ARF was investigated in HIV positive patients it was found that 6 % of their inpatients had ARF with a mortality rate of 27 %. The incidence in the outpatient group the incidence was up to 10 % with approximately one third secondary to drugs³ but HIV infection by itself had also been associated with ARF⁴. One study found that more than half of the episodes of ARF were attributed to infection with 76% of these being an AIDS-defining illness.⁵

Chronic kidney disease

Chronic kidney disease (CKD) is defined as a decrease in GFR $<60\text{ml}/\text{min}/1.73\text{m}^2$ or renal damage (proteinuria, albuminuria, histological abnormalities in the biopsy, the urinary sediment or imaging techniques) that persists for more than three months.⁶ Risk factors for CKD include HTN, DM, advanced age, a low CD4 nadir, a high HIV viral load and the use of potentially nephrotoxic medication.⁷⁻¹¹ The prevalence differs with ethnicity and is higher in areas with less access to treatment.¹² Kidney Disease Improving Global Outcomes (KDIGO) proposed a new classification for prognosis of CKD in 2012 including GFR and albuminuria; the patients are divided into six categories depending on the urinary albumin/creatinine ratio (ACR) and eGFR. The risk outcome events include overall mortality, cardiovascular mortality, renal failure treated with dialysis or transplantation, ARF and progression of renal disease.^{13, 14} Approximately 7.1 % of HIV-infected patients have an estimated GFR (eGFR)¹² $<60\text{ml}/\text{min}/1.73\text{m}^2$ and the prevalence of albuminuria have been measured in several studies to between 11 % and 15.5 %.¹⁵

Antiretroviral drug-induced nephrotoxicity

Nephrotoxicity as a consequence of antiretroviral therapy is uncommon today, although it is suspected that it will increase along with the aging of the population. The risk of having a decrease in eGFR is mostly associated with Non-Nucleoside Reverse Transcriptase Inhibitors (NNRTIs), with Tenofovir (TDF) in particular, and Protease Inhibitors (PIs), such as Atazanavir (ATV) and Lopinavir (LPV). The higher risk of renal toxicity with the above mentioned drugs is controversial and may be due to drug interactions in between the antiretroviral drugs. The toxicity causes functional abnormalities of the tubular proteins,

mainly in the proximal part, causing a clinical picture similar to Fanconi syndrome. This, in full, include phosphaturia, glucosuria with normoglycemia, renal tubular acidosis with normal anion gap, aminoaciduria, tubular proteinuria and medium-long-term renal failure.¹⁶⁻²² The damage caused by TDF toxicity is usually reversible, but may not be complete.²³ One center reported that the administration of TDF each year resulted in a 34 % increased risk of developing proteinuria, 11 % increased risk of rapid decline and a 33 % increased risk of CKD²⁴. Several studies have shown specific toxicity of TDF when used in combination with certain drugs, for example Didanosine. It has been suggested that it might be of greater benefit to regulate the combination of drugs than to exclude TDF, which has demonstrated a positive effect in several randomized control trials. This strategy requires a regular monitoring of kidney function.²⁵

Table 2. Renal toxicity of antiretroviral therapy. Effects of toxicity and their management. According to Johnson RJ, Feehally J, Floege J (2015), p. 685

Renal Toxicity of Antiviral Therapy			
Antiretroviral Class	Antiretroviral Therapy	Renal Effect	Clinical Recommendations
Protease inhibitors	Indinavir	Nephrolithiasis, crystalluria, dysuria, papillary necrosis, acute kidney injury, interstitial nephritis Ritonavir and lopinavir may increase toxicity of indinavir	Daily fluid intake of >2 l/day
	Ritonavir	Reversible AKI (usually in combination with nephrotoxic drugs)	
	Saquinavir, nelfinavir	Renal calculi (rare)	Increased fluid intake
Reverse transcriptase inhibitors	Tenofovir, abacavir	Renal tubular damage: proximal tubular dysfunction, Fanconi syndrome, nephrogenic diabetes insipidus, acute tubular necrosis, AKI	Patients taking tenofovir should be monitored for signs of tubular dysfunction (elevated serum creatinine, hypophosphatemia, low serum uric acid, acidosis glycosuria, proteinuria)
	Didanosine, lamivudine, stavudine	Isolated case reports of tubular dysfunction	
Other	Cidofovir, adefovir	Renal tubular damage, proximal tubular dysfunction (cidofovir)	

Non-antiretroviral drug-induced nephrotoxicity

HIV infected persons might need other drugs during the course of life that are nephrotoxic. This might be due to co-morbidities, opportunistic infections or non-HIV-related conditions. The groups of drugs most commonly implicated are certain Antibiotics and Antivirals, Non-steroidal Anti-inflammatory drugs (NSAIDs), angiotensin converting enzyme (ACE)-inhibitors/angiotensin receptor blockers (ARBs) and iodinated contrasts. These drugs, if possible, should be avoided or dose adjusted according to current kidney function.²

Glomerular and vascular nephropathies

The spectrum of glomerular pathologies is wide and dependent on race, co-infection with Hepatitis C (HCV) virus or any other co-infection, and the control of their HIV. In previous years HIV associated nephropathy (HIVAN) was more prevalent, whereas today older age and cardiovascular causes are more prominent.²⁶

HIV-associated nephropathy

HIV-associated nephropathy (HIVAN) is the best defined type of nephropathy in this population. It is characterized by a focal and segmental collapsing glomerulosclerosis on histology. Clinically the main manifestation is proteinuria, which frequently reaches over 3.5g/24h, although the clinical impact seems to be less severe than patients with other causes of nephrotic syndrome.²⁷ It is more prevalent in the Black than the Caucasian patients with a ratio of 12:1.^{28, 29} The higher prevalence of HIVAN in the black population has been associated with a variant in APOL1 gene. This gene is protecting against trypanosomiasis, but has also been shown to increase the risk of developing kidney disease.^{30, 31} The outcome of HIVAN without ART is poor, often with progression to renal failure requiring dialysis within one year of diagnosis and a high mortality rate.³² Since the introduction of combined ART (cART), the clinical course has improved.³³ Several observational studies have shown a reduced risk of developing HIVAN and improved prognosis with ART, but until today no controlled clinical trials have been performed.³³⁻³⁷ Treatments including ACE-inhibitors or ARBs may delay progression to renal failure. They are indicated when HIVAN is associated with hypertension or proteinuria.³⁸ Some studies showed the benefit of steroid therapy in slowing down the progression to renal failure, but this may in addition to the known side effects be particularly problematic in patients with impaired immunity³⁹ and is not used routinely², but only when it is resistant to therapy with ART and ACE-inhibitor/ARB.³⁹

HIV-associated immune complex kidney disease (HIVICK)

Impaired renal function due to deposits of immune complexes is more common in the HIV-infected persons than in the general population. HIVICK is a histological diagnosis that can have different etiologies with the HIV- infection itself being a cause, post-infectious glomerulonephritis⁴⁰ or a co-infection with HBV- or HCV-infection. Histological appearance is varied, but the clinical manifestations are usually very apparent with macroscopic hematuria, edema, ARF and severe hypertension.² IgA deposits are thought to be a direct consequence of the HIV infection.⁴¹ Sometimes other more discrete manifestations occur

including cryoglobulinemia with evidence of purpura, digestive symptoms and alveolar hemorrhage. Some of these lesions show deposits of IgG and IgM complexes usually associated with HCV-infection, and it has been suggested that this is in fact induced by the HCV infection with the HIV-infection having a marginal role.⁴²⁻⁴⁴ Data on the natural history of HIVICK, treatment options and response to cART are limited⁴⁵⁻⁴⁹, and it is not known whether or not it can be modified through therapies used in HIV-negative patients such as steroids, immunosuppressants and calcineurin inhibitors. In the cases where there is a HCV co-infection studies have shown improvement of renal function with effective anti-hepatitis therapy including Ribavirin and alpha-interferon.^{44, 50}

Diabetic nephropathy and hypertensive nephropathy

The metabolic consequences of antiretroviral therapy include dyslipidemia, body fat changes, insulin resistance and DM. These features are common in the general population as well and tend to increase with age. In the general population the cause of ESRD due to DM and HTN today is as high as 70 %.⁵¹ With the improvement of ART and longer life expectancy it is likely that these features will become more evident in the HIV- infected population as well. Some series of kidney biopsies have shown diabetic nephropathy in 6 % and hypertensive nephropathy in 4 %.^{52, 53} Albuminuria is an independent risk factor for both cardiovascular disease and renal disease⁵⁴, and because it has a high prevalence in the HIV-infected population¹⁵, the incidence in renal disease can be expected to increase in the future.²

Monitoring kidney function

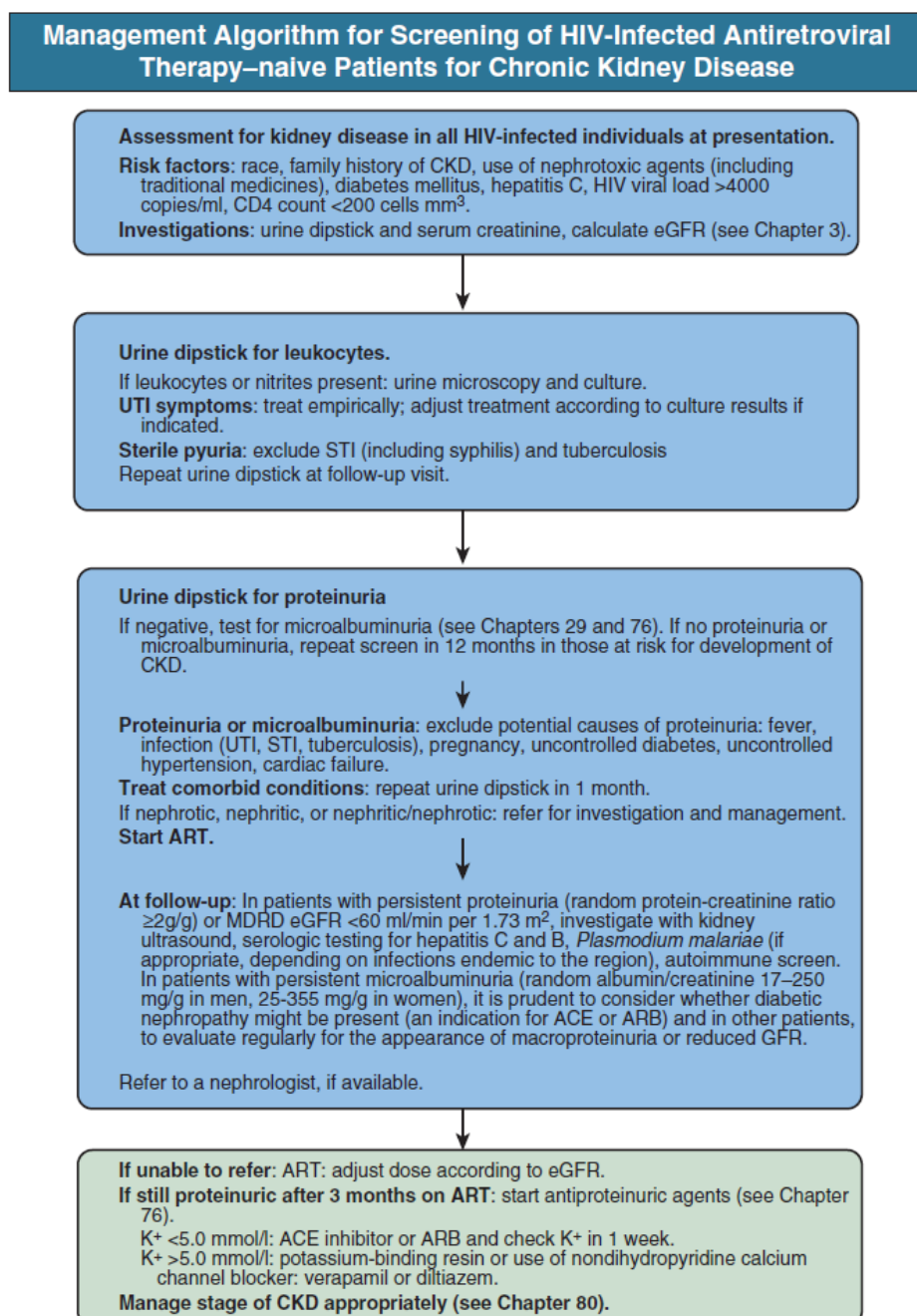
Risk factors for CKD can be classified as modifiable and non-modifiable. The non-modifiable risk factors include race, genetic predisposition and age. The main modifiable risk factors are²

- *Body weight,*
- *Concomitant illnesses* (hypertension, diabetes mellitus, chronic HBV or HCV),
- *Use of potentially toxic drugs* (ART: tenofovir, indinavir; Other: NSAIDs, aminoglycosides, amphotericin B, cidofovir, co-trimoxazole sulfadiazine, acyclovir, foscarnet),
- *HIV associated factors* (viral replication, CD4+ lymphocyte nadir <200 cells/μl, previous diagnosed AIDS).

By keeping the kidney function under control, one can detect renal disease early and adjust the therapy as needed. A basic renal study should include measuring of serum creatinine concentration and eGFR, protein/creatinine ratio (PCR) and albumin/creatinine ratio (ACR) in

the case of hypertension or diabetes, in the first morning urine. Urinary sediment and evaluation of tubular function should also be investigated.²

Table 3. Management algorithm for screening of human immunodeficiency virus (HIV)-infected antiretroviral therapy-naïve patients for chronic kidney disease. Tuberculosis may be pulmonary or extrapulmonary. Antiproteinuric agents may be used in normotensive individuals with gradual up-titration of dose, depending on tolerance and severity of proteinuria. eGFR calculated by CG or MDRD. According to Johnson RJ, Feehally J, Floege J (2015), p. 685



Creatinine Clearance and eGFR

Mocroft et al. compared the estimation of GFR using Cockcroft-Gault (CG) and the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) estimating equations in HIV infection to see if anyone correlated better with kidney function, end-stage renal disease or deaths from kidney disease and all-cause mortality.⁵⁵ The two most used formulae today are the Modification of Diet in Renal Disease (MDRD) and the CKD-EPI, which estimate the glomerular filtration rate⁵⁶, whereas the Cockcroft-Gault formula estimates creatinine clearance. The authors measured eGFR in 133 873 patients with CK standardized for body surface area (BSA) and CKD-EPI and out of them 85.7% were the same with both formulae. The agreement was considerably lower when CK was not standardized for BSA. The cases with discordant measures were more common in those co-infected with HCV, the non-white and those with unknown HIV exposure. In conclusion, they found that CG and CKD-EPI performed equally well in predicting ESRD and all-cause mortality.⁵⁵ Levey et al. found that CKD-EPI was better at estimating GFR than MDRD, especially at higher levels and thus allowing earlier detection and intervention.⁵⁷ The CG have traditionally been used to calculate drug dosages, using serum creatinine concentrations⁵⁸. Although with limited studies performed on eGFR as measurement, some suggest that MDRD gives a good estimation for drug adjustments and can be used instead of CG.^{59, 60}

Protein/creatinine (PCR) or albumin/creatinine ratio (ACR)

Small increases in proteinuria usually precede an increase in serum creatinine and decrease in GFR. Gupta et al. found a correlation with proteinuria in first urine and development of ESRD.⁶¹ Szczech et al. noticed that up to 30 % of their subjects had proteinuria and found risk factors to be elevated HIV RNA level, low CD4+ cell count (<200cells/mm³), black race, and the presence of HCV antibodies.⁶² Hypoalbuminemia was identified as an independent risk factor for the development of ESRD, just as the previously mentioned HIV-associated factors, hypertension, diabetes and cardiovascular disease.⁶³ This shows the clinical significance of following the PCR or ACR. There are different types of proteinuria and it is important to differentiate them.

- *Glomerular proteinuria*: Proteins found in urine are mostly albumin, commonly caused by hypertension and diabetes.
- *Tubular proteinuria*: This type of proteinuria is secondary to tubular toxicity and more often associated with antiretroviral therapy. Proteins found in the urine are usually of

low molecular weight such as α_1 -microglobulin, β_2 -microglobulin, retinol-binding protein, n-acetyl β -glucosamidase or neutrophil gelatinase-associated lipocalin.

- *Mixed proteinuria*: This occurs when there is co-existence of both pathogenic processes.

The procedures for measuring protein in urine are more sensitive for albumin than low molecular weight proteins, which must be present in fairly high concentrations to be detected.^{64, 65} In a study carried out in HIV positive patients, 21% of patients with proteinuria >300mg/g did not test positive with the test strip, but were detected when using PCR.⁶⁶ Many laboratories do not have the technology to detect low molecular weight proteins and the use of ACR can distinguish protein of glomerular origin from that of tubular. By expressing protein content in urine in ratios, estimation errors from using dilute samples can be avoided.^{2, 67}

Renal replacement therapy (RRT)

Until 2001, chronic dialysis was the only available treatment for HIV-positive patients with ESRD in the United States. In Kumar et al. they found that the patient survival at one and two year post transplant was 85 % and 82 % respectively⁶⁸, whereas studies of survival of HIV-positive patients on dialysis have been found to be much lower, 58% and 41% at one and three years respectively.⁶⁹ Between 1990 and 1999, the 1 year survival of HIV-infected patients on dialysis improved from 56% to 74%. Ahuja et al. investigated the survival of HIV positive patients on dialysis to see if the improved survival in the whole population after introduction of HAART applied to those on RRT as well. Until this time RRT did not seem to provide any survival benefit in patients with AIDS, but only in those with still asymptomatic HIV. The poor survival rate made it questionable whether to put HIV infected patients on RRT at all.⁷⁰ The study showed that survival improved from 1997 (two years after HAART was introduced and the same year as it became treatment standard) and onward, but not to the same proportion as in the HIV-negative dialysis patients. One possible mechanism could have been the unknown pharmacokinetic effects of the ART in dialysis.⁶⁹ Trullás et al. made a nationwide multicenter retrospective cohort study of HIV-infected patients on dialysis between 1999 and 2006 in Spain. The subjects were matched with a control group for age, year of starting dialysis, sex, race and dialysis center. The HIV-positive patients five year survival was lower than their HIV-negative counterpart 62.7% and 94.4 %, respectively. The

HIV-positive group was also less likely to be put on the waiting list for transplantation, 17% versus 64 % and less likely to be transplanted.⁷¹

Antiretroviral dosing in patients with renal dysfunction/on dialysis

Today there are guidelines on how to adjust dosing of ART in patients with decreased kidney function; both for those with primary ESRD and those who already received a kidney transplant but later again experienced deteriorating function. The majority of proton pump inhibitors (PIs) and non-nucleoside reverse transcriptase inhibitors (NNRTIs) are metabolized by the liver and does not require any adjustment in kidney disease.⁷² The NRTIs on the other hand are mainly eliminated by the kidneys, both by glomerular filtration and tubular secretion. Dose adjustment in patients with impaired kidney function is important because some of them have nephrotoxic effects, e.g. Tenofovir. NNRTIs do not bind to proteins to a large extent and thus are easily removed by dialysis. PIs on the other hand are extensively bound to plasma proteins and cannot be cleared by dialysis. In Spain HIV-positive patients represent about 0.5% of all patients on dialysis.² The majority are on hemodialysis, but no survival benefit has in general been reported in either hemodialysis or peritoneal type.⁷³

Renal transplantation

The history of organ transplantation started in 1906 when kidneys from different animals were used. Thirty years later human cadaveric kidney transplantation was tried, but it failed due to the fact that the donor and recipient had different blood type. In 1944, the British scientist, Sir Peter Medawar, discovered that rejection was due to immunologic factors and paved the way for the first successful kidney transplantation in 1954⁷⁴. It was performed on identical twins at the Peter Bent Brigham Hospital, in the United States. After this, other organ transplantations followed with improvements in technique and immunosuppressive therapy. In 1983, cyclosporine was approved by FDA and, when administered with corticosteroids, it revolutionized the transplantation medicine. In 1994, tacrolimus was approved further improving outcome and decreasing side effects. In the mid 1990's the question about living donor transplantations was raised due to the organ scarcity. Mycophenolate mofetil was added to the market of immunosuppressives in 1995 and in 1999 sirolimus also. In 2001, the number of living donor organ donations surpassed cadaveric transplantation for the first time in the U.S.⁷⁵

Eligibility for the waiting list

Spital et al. sent out a questionnaire in 1998 to 248 transplantation centers in the U.S. regarding their willingness to put an HIV positive person on the waiting list. All centers answered that they required an HIV test prior to considering transplantation. The result from the questionnaire showed that an HIV-positive patient, who would otherwise be considered good candidates, would be denied a cadaveric transplant in 88 % of the centers and a living transplant in 91 %.⁷⁶ The poor outcomes reported before the HAART-era made their impression on the transplant community and for a long time it was questionable as to whether or not it was morally acceptable to perform such invasive procedure with low chance of success implied that it would be a waste of organs.^{41, 68, 77} The later trials showed good outcomes and similar results to the general population was slowly changed the attitude towards transplantation in the HIV-infected. Now, many guidelines recommend transplantation in the carefully selected patient.^{2 72}

Sawinski et al. reported that HIV-positive patients are less likely to be put on the waiting list for a transplant. Only 20% of theoretical HIV-positive patients were included on the list compared to 70% in the HIV-negative group over the same period of time. They examined the barriers and found several possible factors for this, including lack of documentation of HIV control, CD4+ <200cells/ml³, history of drug use, and African American race⁷⁸. According to the Scientific Registry of Transplant Recipients (SRTR) among the HIV-positive recipients only 33 % of the recipients of living donor organs and 42 % of cadaveric donor organs were of African American descent⁷⁹ although they tend to represent over 80 % of the persons with ESRD within the HIV-positive population.⁸⁰

Specific clinical criteria in the HIV-positive patient considered to be important for a successful transplantation are⁷⁹

- Be free of opportunistic infections
- Compliant with therapy
- Controlled with cART
- Control of CD4+ count > 200 cells/mm³ for at least six months prior to transplantation
- Patients with HBV or HCV co-infection need an additional evaluation by a hepatologist to ensure good liver synthetic function prior to kidney transplantation

- Absence of opportunistic infections or malignancy including a history of progressive multifocal leukoencephalopathy, lymphoma, pulmonary aspergillosis, significant Kaposi sarcoma, or coccidiomycosis, but every case should be evaluated individually

A history of opportunistic infections is not necessarily a contraindication, but those mentioned in the paragraph are since these cannot be treated in an immunocompromised patient.⁴¹ The CD4+ cell count is an important marker of success, with the limit generally set on 200 cells/mm³ for four to six months prior to the transplant and the HIV-RNA should be undetectable, at least <50 cells/ml.⁷⁷ Ideally the patient should not have had an AIDS-defining event and had a psychiatric evaluation. Inclusion criteria for the waiting list are an HIV-infected individual with CKD on RRT or in pre-dialysis phase who meet the general criteria after renal transplantation evaluation and HIV-specific criteria are passed.²

Rodrigue et al. examined the willingness of HIV-positive patients to pursue living donor kidney transplantation (LDKT) in comparison to non-infected.⁸¹ Standardized questionnaires were given to HIV-infected and one non-infected control, matched by year of evaluation, age, sex, race and waiting time was included in the study. They found that the non-infected patients were mostly concerned if they would die if a living donor could not be found. The HIV-positive patients were concerned that no one would volunteer to be a living donor and they would feel guilty if a possible donor was found. They were afraid that the donor of the transplant would be pressured to donating or that the transplant center would be angry with family members if they would not agree to donate. In addition, the HIV-positive group had less knowledge about transplantation and donors than their non-infected counterpart. This included information about donor status, how quickly a donor can return to work, and that kidney donation typically does not increase the risk of future kidney failure. In the non-infected group, 42% considered LDKT, compared to 21 % in the HIV-positive group.⁸¹ Some transplant programs require disclosure of HIV status to potential donors, whereas others do not. The social stigma of having HIV is still very much present today and the study found that most of the patients saw their HIV-status as a barrier to LDKT and felt uncomfortable sharing this information with a potential donor.^{82, 83} The lack of knowledge regarding living donor kidney transplant surprised the authors since the same information was offered to everyone regardless of HIV-status and they speculated that it might reflect their reluctance to pursue this option due to the perceived barrier of their infection. Another fact that stood out was that most HIV-positive patients did not know the current outcomes after kidney transplantation and might therefore be less likely to consider it. The fear of having to disclose their HIV

status, limited knowledge about the possibilities and outcomes of transplantation, and social stigma seem to explain why HIV infected patients are less likely to consider LDKT.⁸¹

The impact of immunosuppression on HIV replication

A reason many did not consider renal transplantation in the HIV-positive patient is the notion that the post-transplant immunosuppressive therapy would lead to progression of the HIV disease.⁸⁴ Further studies on the action of immunosuppressive therapy (IS) in HIV-infected patients provided a reason to believe otherwise. IS could, by disrupting infection of cells by HIV virions or by suppressing T-cell activation, even be beneficial in this patient group.⁷⁹ The human immunodeficiency virus infects a memory CD4⁺ T-cell with a concomitant CCR5 expressed on the cell surface. The central pool of CD4⁺ cells does not express CCR5 and are relatively protected from infection until they become activated. As the cells are infected pro-inflammatory cytokines are released and during chronic HIV-infection there is continuous immune hyperactivation of T-cells.⁸⁵ The persistent viremia together with the consequent depletion of CD4⁺/CCR5 cells seems to be especially prominent in the gut mucosa (GALT) leading to translocation of bacteria through the intestinal epithelium. This exposes the patient to inflammatory mediators such as bacterial lipopolysaccharides further stimulating the ongoing immune reaction.⁸⁶ An antibody response can further worsen the situation by binding to the infected cells causing complement activation and immune complex deposition.⁸⁷ Even those effectively treated with ART have a continuous chronic inflammatory response which may be a cause of tissue damage.⁷⁹

Studies have shown that the cellular protein cyclophilin A is required for maturation of the HIV-1 and subsequently for its ability to infect other cells.^{88,89} Both cyclosporin A (CsA) and tacrolimus (Tac) have been demonstrated to impact HIV replication. In vitro studies showed how CsA binds to cyclophilin A and suppresses IL-2 mediated lymphocyte activation, decreases infectivity of naive cells and inhibits viral production in chronically infected cells.⁹⁰ Tac interfere only with growth of chronically infected cells, but do not decrease infectivity as seen with CsA.⁹¹ Sirolimus reduces CCR5 expression and causes suppression of the HIV-1 replication in vitro at concentrations far lower than the therapeutic dose for immunosuppression in kidney transplant recipients.⁹²

One study compared the treatment of patients newly diagnosed HIV treated with only HAART and a group treated with HAART and concomitant cyclosporin A. At the end of the study viral replication was equally suppressed, but the CD4⁺ cell count was significantly

higher in the group treated with both HAART and cyclosporine. This finding suggests that immunosuppression prevent the inflammatory trigger to cause activation of central CD4+ cells and thus also prevent them from being infected, could have a beneficial effect.⁸⁴

Outcome after transplantation

In the pre-HAART era, the outcome after solid organ transplantation in the HIV-infected patient was poor, leading to shorter AIDS-free interval and frequently death due to AIDS or AIDS-related complications.⁹³⁻⁹⁵ The pilot study performed by Stock et al. in 2007 challenged the odds of the previous reports. This was done in the setting of better control of HIV, since the introduction of HAART in 1996, and more effective prophylaxis and management of opportunistic infections.⁹⁶

Kumar et al. performed one of the earlier studies on the outcome of renal transplantation in the HIV-positive group. Clinical acute rejection occurred more frequently than in the non-HIV group and they speculated that the reason might be that they used lower level of immunosuppression to avoid opportunistic infections. Ultimately the graft survival was comparable to other high risk groups, and the patients had better survival than those who were maintained on dialysis. They noted that the majority of their subjects were African-American (97%) and that half of the kidneys came from marginal donors⁶⁸, factors that on their own are associated with a lower rate of graft survival.⁹⁷

Qiu et al. used information from the UNOS Renal transplant registry to study the outcome after renal transplantation when one of the donor kidneys went to a HIV-positive recipient and the other to a HIV-negative recipient. Although they admitted low power, the study showed a statistically significant survival rate that was similar in both patient groups. The survival was even slightly better in the HIV-positive group, possibly due to stricter selection criteria, the fact that they in general were younger or that they had lower levels of PRA. The HIV-positive cohort had higher creatinine values which could be due to the nephrotoxic effect of ART that can occur with the intricate interactions with the immunosuppressive therapy.⁹⁸

Roland et al. conducted a prospective study of liver and kidney transplantation in the HIV-infected patients and recorded the patient, graft and HIV related outcomes. With a median follow up of three years, patient survival was approximately 94 % and graft survival was 83 % after one and 3 years, respectively. The reasons for rejection were severe acute rejection, chronic rejection and vascular thrombosis. Both patient and graft survival were similar to the general population transplanted at the age of 65 or older, as reported from the Organ

Procurement and Transplantation Network (OTPN)⁹⁹. *Candida* esophagitis was reported in one patient with diabetes, previously treated with thymoglobulin for an event of acute rejection, but who recovered with antifungal treatment. The cumulative incidence of allograft rejection at 1, 2 and 3 year reached 52 % in the kidney transplant recipients. Hazard ratios were increased and found statistically significant only for age and panel reactive antibodies (PRA) levels at transplant. Other factors, such as most recent CD4+ cell count, antigen mismatch, use of ART and delayed initiation of cyclosporine were speculated to have influence, but could not be proven due to the low power of the study. They made the observation that the patients with episodes of rejection had a higher median creatinine value.¹⁰⁰

The Croatian case report shows similar results with an HIV-infected patient under good control prior to transplantation, standard induction therapy (prednisolone, tacrolimus, mycophenolate mofetil and basiliximab). The patient experienced coagulation abnormalities with bleeding despite normal coagulogram, Non ST-elevation myocardial infarction (NSTEMI), *psuedomonas* pneumonia and borderline acute rejection requiring a period of dialysis. The patient improved with three boluses of methylprednisolone and was ready for discharge two months after transplantation. The patient was under the care of a multidisciplinary team with nephrologists, urologists and infectologists.¹⁰¹

An evidence-based analysis on the outcome of solid organ transplantation in the HIV-positive patient concluded that the risk of death after kidney transplantation did not differ between HIV-positive and -negative patients although they found the level of evidence to be very low. The same low evidence made the result of insignificant difference in risk of acute rejection between HIV-positive and HIV-negative uncertain.¹⁰²

Infection

The majority of infections reported after kidney transplantation have typically not been opportunistic in nature,^{68, 96} but the use of thymoglobulin has been associated with opportunistic infections in several studies.^{96, 100}

Proper prophylaxis against opportunistic infections is essential. Today these include cytomegalovirus, toxoplasmosis, pneumocystis carinii pneumoniae, mycobacterium avium complex, cryptococcosis and histoplasmosis.⁴¹ Additionally recommended prophylaxis include tuberculosis, hepatitis A and B, *Streptococcus pneumoniae*, chicken pox and *Hemophilus influenzae B*.⁷⁷

Table 4. Opportunistic infections and their treatment. **Reproduced with the permission from Wolters Kluwer Health.**⁴¹

Condition	Primary prophylaxis ^a	Secondary prophylaxis ^b
<i>Pneumocystis carinii</i> pneumonia	Indicated for life; Initiate immediately posttransplant Preferred: TMP-SMX Alternative: dapsone, if not G6PD deficient, atovaquone	Indicated for life; Initiate immediately posttransplant Preferred: TMP-SMX Alternative: Dapsone if not G6PD deficient, atovaquone
Toxoplasmosis	Toxoplasmosis IgG-positive patients with CD4+ T cell count \leq 200 Preferred: TMP-SMX Alternative: atovaquone, sulfadiazine + pyrimethamine + leucovorin	CD4+ T cell count $<$ 200 cells/mL. Discontinue when CD4+ cell count is $>$ 200 cells/mL for 3-6 months Alternative: atovaquone, sulfadiazine + pyrimethamine + leucovorin
<i>Mycobacterium avium</i> complex	Indicated when CD4+ T cell count is \leq 50 cells/mL. Discontinue when CD4 count is above 100 cells/mL for 3-6 months. Preferred: azithromycin 1200mg weekly Alternative: clarithromycin	Cell count 50 cells/mL Discontinue when CD4 count is above 100 cells/mL for 3-6 months. Alternative: clarithromycin ' ethambutol
Cytomegalovirus	No HIV-specific indication	Cell count 75-100 cells/mL Discontinue when CD4+ T cell count is above 100-200 cells/mL for 3-6 months. Preferred: valganciclovir Alternative: foscarnet, cidofovir
Cryptococcosis, extrapulmonary	No HIV-specific indication	CD4+ cell count below 200 cells/mL. Discontinue when CD4+ cell count is above 200 cells/mL for 3-6 months ^c Fluconazole
Histoplasmosis	No HIV-specific indication	Continue regardless of CD4+ cell count Itraconazole

- *a* No history of the infection
- *b* Prior history of the infection
- *c* Secondary prophylaxis should also be reinstated immediately posttransplant for 1 month and during the treatment of acute rejection for 1 month following completion of acute rejection therapy. If the CD4+ T cell count is suppressed, continuation should be guided by the CD4+ T cell count.

Rejection

The rate of rejection is much higher than in that of the general population, sometimes as high as two or three times. Despite this number, the overall graft survival is not different from the non-HIV transplanted.⁷⁷ It is believed that the immune system of an HIV positive patient is dysregulated rather than just suppressed. This is supposed to be the cause at least in the cases of very early rejection.⁹⁶ Another theory is that the complex drug interactions cause fluctuations in the blood concentrations of the immunosuppressive therapy opening up to

rejection.^{96, 100} Today, most of the episodes of rejections are susceptible to therapy with either corticosteroids or, in more severe cases, thymoglobulin.⁷⁹

Drug interactions

Drug interactions between IS and ART are a big concern in the transplanted HIV patients. The interactions are unpredictable and are not the same even within groups of ARTs. The impact of these uncertain drug levels can lead to either toxicity or suboptimal immunosuppression. The main interactions seem to be between calcineurin inhibitors (CNI) and protease inhibitors (PI). Many of the PIs inhibit CYP-450 3A, which are responsible for metabolizing both immunosuppressants and other ARTs.¹⁰³ The efflux transporter P-glycoprotein (P-gp) is predominantly found on the apical side of intestinal and hepatic epithelial cells and act to decrease absorption and increase excretion of its substrates. Normally in intestinal cells, P-gp and CYP3A4 act to decrease absorption and increase drug metabolism. Concomitant administration of immunosuppressant and ART acting on these processes is expected to decrease their metabolism while increasing their uptake, leading to higher systemic blood levels.¹⁰⁴ P-glycoprotein is another substrate for the PIs¹⁰⁵. Frassetto et al. 2013 described the pharmacokinetics of concomitant administration of ART and IS in a longitudinal study. In the first three months after transplant when CsA was given together with a PI only 1/10 of the dose necessary for the non-HIV patients was enough to reach therapeutic blood levels. The dose of CsA had to be higher when given with Efavirenz (EFV) than when given together with Nevirapine (NVP), and both were significantly higher than if it was administered with PIs in week 2-12. Bioavailability of CsA, when given concomitantly with EFV increased over time, whereas there was no time dependent change when co-administered with PIs or NVP. In a combination dose of PI+NVP the CsA dose increased by about 30 % with almost unchanged AUC. With tacrolimus the dose had to be lowered significantly when given together with PIs with exposure increasing 10-fold, but was not affected significantly by NVP or EFV. The increased bioavailability of TAC with PI was significantly higher than for CsA.¹⁰⁴

A higher level of IS is associated with a lower risk of rejection. Frassetto et al. found that giving a PI (CYP450 inhibitor) and a non nucleoside reverse transcriptase inhibitor (NNRTI) (CYP450 inducer) together, did not produce the estimated intermediate effect on the IS metabolism. Due to different potencies, the additional effect on the P-gp and probably several unknown transporters, the resulting trough levels are unpredictable. The conclusion was that

EFV and NVP affected CsA differently over time, making predictions according to group inaccurate.¹⁰⁴

When using PIs and CNIs, the dosages of CNIs must be significantly reduced or the dosing free intervals extended. Tacrolimus is a substrate for both CYP 450 3A and P-glycoprotein. The latter is responsible for the drug's entry into lymphocytes, through the blood brain barrier and into tissues. There seems to be almost identical features with cyclosporine, but it has been less extensively tested in vitro. There are also studies showing different tacrolimus drug interactions between gender and ethnicities.¹⁰⁶ Sirolimus and Everolimus are also substrates for P-450 and P-glycoprotein and have been reported to react similarly, but only limited data exist.¹⁰⁷

The non-nucleoside reverse transcriptase inhibitors NNRTs are p-450 substrate inducers and can lead to increased metabolism of CNIs or sirolimus with consequent sub-optimal levels in the blood.¹⁰⁷ The NRTs are not substrates for the p-450 system, but may contribute to both anemia and neutropenia. This together with the effect of some immunosuppressive drugs, may cause severe leukopenia and CD4+ cell depletion.⁷⁹

The active metabolite of MMF, mycophenolic acid, interferes with the conversion of inosine monophosphate (IMP) to guanosine monophosphate (GMP). Some in vitro studies showed several interactions between MMF and ART, including abacavir, didanosine and tenofovir.⁷⁹ Apart from its interactions it seems as though the depletion of GMP, the substrate for reverse transcriptase in the virus infected cells, might prevent replication of the virus and even induce apoptosis of activated CD4+ cells in vitro with the result of hampering the infection.¹⁰⁹ Glucocorticoids are, like the NNRTs, inducers of the p-450 system. The tapering of the steroid dose that typically starts after transplantation may be accompanied by changes with increased blood concentrations of CNIs and decreased CD4+ cell counts. This consequently puts the patient at a higher risk of nephrotoxicity and infection.¹⁰⁹

Drug selection in the transplant recipient

Different immunosuppressive regimens have been tried and so far there is no convincing evidence that one is superior to the other.⁷⁷ In addition to the usual challenge of balancing the risk of rejection and opportunistic infections this patient group have the drug interactions between the immunosuppressants and the ART.⁷⁹ For the induction therapy, many are trying

to avoid lymphocyte-depleting drugs, e.g. thymoglobulin, because it can cause a very low CD4+ T cell count for an unpredictable duration of time⁷⁷. Several authors have noticed an increased frequency of infections with this drug.⁹⁶ High immunologic risk patients usually receive a more aggressive induction therapy pre-transplantation; typically they receive antithymocyte globulin or an IL-1 receptor antibody.¹¹⁰ The use of glucocorticoids and IL-2-inhibitors made lymphocyte-depleting drug-sparing regimens possible.⁷⁷

The maintenance therapy today typically consists of three components: a CNI (e.g. cyclosporine or tacrolimus), an anti-metabolite (e.g. mycophenolate mofetil) and corticosteroids.^{77,79} CsA is commonly favored because of its positive effect on both antiretroviral and immunosuppressive effects.^{79, 90, 91} It has been preferred over TAC in part due to the latter having an increased risk of inducing glucose intolerance,^{77, 96, 101} but recent evidence suggests that CsA is associated with rejection episodes, although without loss of graft.⁹⁸ MMF deplete intracellular nucleotides and thus have antiretroviral properties and synergistic effects with certain NRTs, such as didanosine and abacavir.^{30, 77}

Sirolimus is, in addition to downregulating the CCR5 expression, an anti-proliferative agent that is useful in the treatment of Kaposi sarcoma and it has been suggested that it could be used beneficially in cancer occurring post-transplant. It can be a good alternative in those experiencing cyclosporine toxicity or decreased renal function of other etiology.⁷⁷

There are five groups of antiretroviral drugs: nucleoside reverse transcriptase inhibitors (NRTI), non-nucleoside reverse transcriptase inhibitors (NNRTIS), protease inhibitors (PI), entrance inhibitors and integrase inhibitors. Usually a combination of three is used and the goal is to set a regimen that can be continued post-transplantation. Tenofovir is associated with both acute and chronic declines in renal function and should be used with caution in transplant recipients.⁷⁹ Combination pills usually have to be avoided in patients with impaired kidney function due to the need to individualize dosing regimens of the different drugs and requirement to adjust them over time.¹⁰⁴

CCR5 is a co-receptor needed for HIV to infect CD4+ T cells and those who are homozygous for CCR5 Δ 32 mutation causing a non-functioning receptor are resistant to HIV infection. This receptor was found to be upregulated in cases of acute rejection and drugs deactivating this receptor has become of interest in transplantation medicine.¹¹³ Fischereder et al. studied the outcomes after renal transplantation in patients homozygous for CCR5 Δ 32 mutation, heterozygous and homozygous wild-type. The results were statistically significant with improved graft survival in the CCR5 Δ 32 homozygous group compared to the heterozygous and those with wild-type mutation.¹¹² Heidelhain et al. got similar results.¹¹³ The CCR5-

antagonist maraviroc, (ART), was tested in patients receiving hematopoietic stem cell transplantation (HSCT) and proved to have lower incidence of visceral GVHD. Maraviroc hampers chemotaxis without interfering with the function of the T cells.¹¹⁴

Corticosteroid-sparing regimen

Corticosteroids are a part of the maintenance therapy after transplantation in many regimens, but have an increased risk of cardiovascular events.¹¹⁵ Early withdrawal regimens have been tried in HIV-negative kidney transplantation. Knight et al. performed a meta-analysis of kidney transplantation where steroid avoidance or withdrawal (SAW) protocol had been followed. They found an increased risk of acute rejection episodes, although with only a marginal effect on graft survival and that cardiovascular risk factors, measured by HTN, DM and hypercholesterolemia, were greatly decreased.¹¹⁶ Very early steroid withdrawal (VESW), when corticosteroids is removed before day three post-transplantation, was studied. In a meta-analysis of RCTs of renal transplantations and VESW protocol, an increased rate of acute rejection was found, although they were mild episodes that were mostly amenable to therapy. They found that this difference lost significance for the patients receiving TAC, but maintained for those on CsA. VESW was associated with delayed graft function (DGF). Cardiovascular risk factors were significantly reduced with this protocol. In conclusion it was safe to withdraw corticosteroids early, but longer than three days would decrease the risk of DGF.¹¹⁷ Muthukumar et al. tried SAW in the kidney transplantations of 11 consecutive HIV-infected patients. The authors used an anti-thymocyte globulin agent as the primary induction agent, intravenous methylprednisolone day 0-4 and maintenance therapy with tacrolimus and mycophenolate mofetil without any corticosteroids. All patients were low-risk and maintained on HAART both before and after transplantation. One year patient survival was 100% and allograft was 91%; at three years it was 90% and 81 % respectively. One patient died of uncertain causes; it was believed to be of cardiovascular reason, but the subject had a stable graft function on the last check up. The causes of rejection were primary non-function and acute rejection. Two episodes of acute rejection were treated with pulse methylprednisolone, immunoglobulins and plasmapheresis, but both grafts failed despite this. No progression of HIV-disease was reported, measured by increased number of viral copies. Complications included infections and cancer, all successfully treated. Overall the graft and patient survival were comparable to larger studies done in the HIV-positive population with non-steroid sparing treatment and with seemingly reduced cardiovascular risk. No patient had any change in weight, blood pressure or lipid lowering drugs and no new onset of diabetes mellitus after

transplant (NODAT). The results were promising, but should be interpreted with caution due to its low power and lack of control group.¹¹⁸

Combined liver and kidney transplantation in the HBV/HCV-HIV infected patient

Many patients with HIV are co-infected with HBV or HCV, in some studies as high as 50 %, due to a common route of transmission.¹⁰² The infections affect each other; the HCV infection can promote an antibody-antigen complex glomerulonephritis and cause ESRD and the treatment of HIV with ART can hasten the progression to end-stage liver disease in the person with HCV-infection. The HCV/HIV co-infected patient has a poorer response to anti-hepatitis medication, mostly pegylated interferon (IFN) and ribavirin, and they have many interactions with ART. Post-renal transplantation immunosuppression is believed to activate HCV replication and accelerate the development of end-stage liver disease. Furthermore IFN therapy is contraindicated in the renal transplant patient.¹¹⁹ End stage liver disease, many times due to HCV-infection and its sequelae (cirrhosis, liver failure and hepatocellular carcinoma) is now a leading non-AIDS cause of death in the HIV-positive patient in the developed world.^{77,120} Patients with HIV-infection and concomitant liver failure have a poorer pre-transplant survival rate than the HIV-negative corresponding group.¹²¹ HBV infection has no negative effect on graft- or patient survival after kidney transplantation. Patients with a co-infection of HCV have shown variable results after transplantation. The Ontario Health Technology Assessment Series evidence based analysis, made in 2010, found that the risk of death after transplantation was 2.8 times higher in the co-infected (HIV+/HCV+) than the mono-infected (HIV-/HCV+).¹⁰² One study attributed the lower graft and patient survival to older age, combined liver-kidney transplantation, an anti-HCV-positive donor and a BMI <21kg/m². Without these factors the survival rates were the same as after transplantation in a HCV mono-infected patient. Many patients experience HCV recurrence following transplantation contributing to the lower survival.⁷⁷ The new anti-viral drugs for HCV, called direct-acting antivirals have so far limited experience, but show promising results. Concerns regarding drug-drug interactions with the HIV ART still exist.¹²² Eligibility criteria are somewhat different in this group than the monotransplant kidney patients; In some combined liver-kidney transplantations the viral load can be accepted to be higher if the patient cannot tolerate HAART due to poor liver function and drug associated hepatotoxicity. BMI should be > 21kg/m².⁷³

Discussion

The history of HIV/AIDS is a relatively short one. It appeared in the 1980's and a diagnosis meant a certain and imminent death and today it can be considered to be a chronic disease. Many times the disease was associated with homosexuals, intravenous drug abusers and black people, but later spread to transplant recipients and other groups of society. Since the introduction of the first anti-HIV drug in 1987, and later HAART in 1995, the future of HIV/AIDS patients changed quickly. In the developed world the morbidity in this population has become more similar to the general population with hypertension, diabetes and end-organ failure. This group is even more susceptible to these conditions due to side effects of the cART. Transplantation as treatment of end-organ failure in the HIV-positive patient has long been considered futile. There have been many and major obstacles to successful transplantation, but they are being overcome one at the time. In the beginning the short life span of the infected person made transplantation a dangerous procedure that did not improve neither the quality of life nor the possibility of survival of the patient and was thus considered a waste of scarce organs. Many feared that the immunosuppression from the transplantation therapy would cause unlimited viral replication and hasten the progression to AIDS and death. HAART allowed better controlled HIV and some started performing transplantation in well regulated patients. The results were significantly better than before, but still lower than the general population. It was speculated that this could be because they received suboptimal immunosuppression, organs from marginal donors and that they were mostly Black, all which historically were associated with a poorer outcome. The realization that immunosuppressive treatment might actually have a beneficial effect on HIV has increased the willingness to perform transplantation in this group. With time knowledge, novel drugs and treatment regimens, and experience of the treating physicians from all relevant fields in medicine led to better results. Still, acute rejection episodes are more common in this population, but are rarely leading to graft failure.

The HIV-positive patient population with ESRD, who require and is eligible for transplantation, is still relatively small and scattered over the world, making it difficult to attain large power studies to provide strong evidence. The research that are done using information from bigger data registries often encounter problems of missing data and inconsistent use of parameters, making comparisons difficult.

One of the issues today regarding transplantation is concerning optimal drug regimen. Complex drug interactions that are different between and within groups of drugs regarding

metabolism, excretion and bioavailability require regular and continuous checkups of drug concentrations in blood. A multidisciplinary team including infectious disease specialists and nephrologists is recommended for a better understanding and an optimal choice of drugs. The improved survival rates and graft function have allowed cardiovascular and other long term risk factors to be taken into account and different types of early corticosteroid withdrawal protocols are being tried.

An HIV-positive patient with end-organ failure is less likely to end up on the transplant list than his HIV-negative counterpart. The diagnosis of HIV is associated with a social stigma that can lead to less HIV positive patients to receive transplants. In countries like the United States, with a large Black population there is an underrepresentation of this subgroup even within the HIV-positive transplant recipients. Reluctance to revealing their HIV status to the donor and less awareness of the benefits of this treatment option were identified as possible causes. Specialized support groups and educational programs might be needed for these patients to learn about their options and be able to consider transplantation in light of the current research.

Conclusion

The studies performed with renal transplantation in the HIV-positive patients since the introduction of HAART has demonstrated continuously improving survival of both graft and patient, and today it is similar to those of the HIV-negative population. The question of whether it is beneficial to perform renal transplantation in the HIV-positive population were affirmative in the later studies, reviews and meta-analyses although they all admitted to low power due to small study sample sizes. In conclusion, more research has to be done to gain greater level of evidence, but regarding the disease and its management we have come to a point where the outcome of renal transplantation is similar to the general population and should be offered to anyone fulfilling the criteria.

Sources

1. <https://www.aids.gov/hiv-aids-basics/hiv-aids-101/aids-timeline/>
2. AIDS Working Group (GESIDA) of the Spanish Society of Infectious Diseases and Clinical Microbiology (SEIMC); Spanish Society of Nephrology (S.E.N.); Spanish Society of Clinical Chemistry and Molecular Pathology (SEQC), Górriz JL, Gutiérrez F, Trullas JC, Arazo P, Arribas JR, Barril G, Cervero M, Cofan F, Domingo P, Estrada V, Fulladosa X, Galindo MJ, Gracia S, Iribarren JA, Knobel H, López-Aldegue J, Lozano F, Martínez-Castelao A, Martínez E, Mazuecos MA, Miralles C, Montañés R, Negro E, Palacios R, Pérez-Eliás MJ, Portilla J, Praga M, Quereda C, Rivero A, Santamaría JM, Sanz J, Sanz J, Miró JM. Consensus documents on the management of renal disease in HIV-infected patients. *Nefrologia*. 2014 Sep 18;34 Suppl 2:1-81

3. Kalim S, Szczech LA, Wyatt CM. Acute kidney injury in HIV-infected patients. *Semin Nephrol.* 2008 Nov;28(6):556-62
4. Ibrahim F, Naftalin C, Cheserem W, Roe J, Campbell LJ, Bansi L, Hendry BM, Sabin C, Post FA; Immunodeficiency and renal impairment are risk factors for HIV-associated acute renal failure. *AIDS;* 2010 Sep; 10;24(14):2239-44
5. www.hivguidelines.org
6. http://www2.kidney.org/professionals/KDOQI/guidelines_ckd/p4_class_g1.htm
7. Ando M, Yanagisawa N, Ajisawa A, Tsuchiya K, Nitta K. A simple model for predicting incidence of chronic kidney disease in HIV-infected patients. *Clin Exp Nephrol.* 2011 Apr;15(2):242-7.
8. Winston J, Deray G, Hawkins T, Szczech L, Wyatt C, Young B. Kidney disease in patients with HIV infection and AIDS. *Clin Infect Dis.* 2008 Dec 1;47(11):1449-57.
9. Sorlí ML, Guelar A, Montero M, González A, Rodríguez E, Knobel H. Chronic kidney disease prevalence and risk factors among HIV-infected patients. *J Acquir Immune Defic Syndr.* 2008 Aug 1;48(4):506-8.
10. Fine DM, Perazella MA, Lucas GM, Atta MG. Renal disease in patients with HIV infection: epidemiology, pathogenesis and management. *Drugs.* 2008;68(7):963-80.
11. Emem CP, Arogundade F, Sanusi A, Adelusola K, Wokoma F, Akinsola A. Renal disease in HIV-seropositive patients in Nigeria: an assessment of prevalence, clinical features and risk factors. *Nephrol Dial Transplant.* 2008 Feb;23(2):741-6.
12. Wyatt CM, Winston JA, Malvestutto CD, Fishbein DA, Barash I, Cohen AJ, Klotman ME, Klotman PE. Chronic kidney disease in HIV infection: an urban epidemic. *AIDS;* 2007 Oct 1;21(15):2101-3
13. Akbari A, Clase CM, Acott P, Battistella M, Bello A, Feltsmate P Grill A, Karsanji M, Komenda P, Madore F, Manns BJ, Mahdavi S, Mustafa RA, Smyth A, Welcher ES. Canadian Society of Nephrology Commentary on KDIGO Clinical Practice Guideline for CKD evaluation and management. *Am J Kidney Dis.* 2014 Nov; S0272-6386(14)01356-0.
14. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease, volume 3, issue 1, jan 2013
15. Choi AI, Rodriguez RA, Bachetti P, Berthenthal D, Volberdin PA, O'Hare AM. Racial differences in end-stage renal disease rates in HIV infection versus diabetes. *J Am Soc Nephrol* 2007;18:2968-74
16. Mocroft A, Kirk O, Reiss P, De Wit S, Sedlacek D, Beniowski M, et al.; EuroSIDA Study Group. Estimated glomerular filtration rate, chronic kidney disease and antiretroviral drug use in HIV-positive patients. *AIDS* 2010;24(11):1667-78.
17. Scherzer R, Estrella M, Li Y, Choi AI, Deeks SG, Grunfeld C, et al. Association of tenofovir exposure with kidney disease risk in HIV infection. *AIDS* 2012;26(7):867-75.
18. Fine DM, Gallant JE. Nephrotoxicity of antiretroviral agents: is the list getting longer? *J Infect Dis* 2013;207(9):1349-51.
19. Rasch MG, Engsig FN, Feldt-Rasmussen B, Kirk O, Kronborg G, Pedersen C, et al. Renal function and incidence of chronic kidney disease in HIV patients: a Danish cohort study. *Scand J Infect Dis* 2012;44(9):689-96.
20. Young J, Schafer J, Fux CA, Furrer H, Bernasconi E, Vernazza P, et al.; Swiss HIV Cohort Study. Renal function in patients with HIV starting therapy with tenofovir and either efavirenz, lopinavir or atazanavir. *AIDS* 2012;26(5):567-75.
21. Reynes J, Trinh R, Pulido F, Soto-Malave R, Gathe J, Qaqish R, et al. Lopinavir/ritonavir combined with raltegravir or tenofovir/emtricitabine in antiretroviral-naïve subjects: 96-week results of the PROGRESS study. *AIDS Res Hum Retroviruses* 2013;29(2):256-65.
22. Yombi JC, Pozniak A, Boffito M, Jones R, Khoo S, Levy J, et al. Antiretrovirals and the kidney in current clinical practice: renal pharmacokinetics, alterations of renal function and renal toxicity. *AIDS* 2014;28:621-32.
23. Wever K, van Agtmael MA, Carr A. Incomplete reversibility of tenofovir-related renal toxicity in HIV-infected men. *J Acquir Immune Defic Syndr* 2010;55(1):78-81.
24. Scherzer R, Estrella M, Li Y, Deeks SG, Grunfeld C, Shlipak MG. Association of Tenofovir exposure with kidney disease risk in HIV infection. *AIDS.* 2012 April; 26(7):867-875
25. Cooper RD, Wiebe N, Smith N, Keiser P, Naicker S, Tonelli M. Systematic review and Meta-analysis: Renal safety of Tenofovir Disoproxil Fumarate in HIV-

- infected patients. *Clin Infect Dis*. 2010 Sep 1;51(5):496-505
26. Lescure FX, Flateau C, Pacanowski J, Brocheriou I, Rondeau E, Girard PM, et al. HIV-associated kidney glomerular diseases: changes with time and HAART. *Nephrol Dial Transplant* 2012;27(6):2349-55.
 27. Laradi A, Mallet A, Beaufils H, Allouache M, Martinez F. HIV-associated nephropathy: outcome and prognosis factors. Groupe d' Etudes Nephrologiques d'Ile de France. *J Am Soc Nephrol* 1998;9(12):2327-35.
 28. Herman ES, Klotman PE. HIV-associated nephropathy. Epidemiology, pathogenesis, and treatment. *Semin Nephrol* 2003;23(2):200-8.
 29. Humphreys MH. Human immunodeficiency virus-associated glomerulosclerosis. *Kidney Int* 1995;48(2):311-20.
 30. Papeta N, Kiryluk K, Patel A, Sterken R, Kacak N, Snyder HJ, Imus PH, Mhatre AN, Lawani AK, Julian BA, Wyatt RJ, Novak J, Wyatt CM, Ross MJ, Winston JA, Klotman ME, Cohen DJ, Appel GB, D'Agati VD, Klotman PE, Gharavi AG. APOL1 variants increase risk for FSGS and HIVAN but not IgA nephropathy. *J Am Soc Nephrol*. 2011 Nov;22(11):1991-6
 31. Thomson R, Genovese G, Canon C, Kovacsics D, Higgins MK, Carrington M, Winkler CA, Kopp J, Rotimi C, Adeyemo A, Doumatey A, Avodo G, Alper SL, Pollak MR, Friedman DJ, Raper J. Evolution of the primate trypanolytic factor APOL1. *Proc Natl Acad Sci U.S.A.* 2014 May 20;111(20):E2130-9
 32. Glasscock RJ, Cohen AH, Danovitch G, Parsa KP. Human immunodeficiency virus (HIV) infection and the kidney. *Ann Intern Med* 1990;112(1):35-49.
 33. Lescure FX, Flateau C, Pacanowski J, Brocheriou I, Rondeau E, Girard PM, et al. HIV-associated kidney glomerular diseases: changes with time and HAART. *Nephrol Dial Transplant* 2012;27:2349-55.
 34. Schwartz EJ, Szczech LA, Ross MJ, Klotman ME, Winston JA, Klotman PE. Highly active antiretroviral therapy and the epidemic of HIV end-stage renal disease. *J Am Soc Nephrol* 2005;16(8):2412-20.
 35. Lucas GM, Eustace JA, Sozio S, Mentari EK, Appiah KA, Moore RD. Highly active antiretroviral therapy and the incidence of HIV-1-associated nephropathy: a 12-year cohort study. *AIDS* 2004;18(3):541-6.
 36. Wali RK, Drachenberg CI, Papadimitriou JC, Keay S, Ramos E. HIV-1-associated nephropathy and response to highly-active antiretroviral therapy. *Lancet* 1998;352(9130):783-4.
 37. Atta MG, Gallant JE, Rahman MH, Nagajothi N, Racusen LC, Scheel PJ, et al. Antiretroviral therapy in the treatment of HIV-associated nephropathy. *Nephrol Dial Transplant* 2006;21(10):2809-13.
 38. Wei A, Burns GC, Williams BA, Mohammed NB, Visintainer P, Sivak SL. Long-term renal survival in HIV-associated nephropathy with angiotensin-converting enzyme inhibition. *Kidney Int* 2003;64(4):1462-71.
 39. Smith MC, Pawar R, Carey JT, Graham RC, Jr., Jacobs GH, Menon A, et al. Effect of corticosteroid therapy on human immunodeficiency virus-associated nephropathy. *Am J Med* 1994;97(2):145-51.
 40. Foy MC, Estrella MM, Lucas GM, Tahir F, Fine DM, Moore RD, Atta MG. Comparison of risk factors and outcomes in HIV immune complex kidney disease and HIV-associated nephropathy
 41. Stock PG, Roland M. Evolving clinical strategies for transplantation in the HIV-positive recipient. *Transplantation*. 2007;84:563-71
 42. Morales E, Alegre R, Herrero JC, Morales JM, Ortuno T, Praga M. Hepatitis-C-virus-associated cryoglobulinaemic membranoproliferative glomerulonephritis in patients infected by HIV. *Nephrol Dial Transplant* 1997;12(9):1980-4.
 43. Gupta SK, Mamlin BW, Johnson CS, Dollins MD, Topf JM, Dube MP. Prevalence of proteinuria and the development of chronic kidney disease in HIV-infected patients. *Clin Nephrol* 2004;61(1):1-6.
 44. Praga M, Gutierrez Solis E, Morales E. Hepatitis C-induced renal disease in patients with AIDS: an emergent problem. *Contrib Nephrol* 2012;176:24-34.
 45. Diallo AD, Nochy D, Niamkey E, Yao B. Etiological aspects of nephrotic syndrome in black African adults in a hospital setting in Abidjan. *Bull Soc Pathol Exot* 1997;90:342-345
 46. Nochy D, Glotz D, Dosquet P, Pruna A, Guettier C, Weiss L, Hinglais N, Idatte JM, Mery JP, Kazatchkine M, Druet P, Bariety J. Renal disease associated with HIV-infection: A multicentric study of 60 patients from Paris hospitals. *Nephrol Dial Transplant* 1993; 8:11-19.
 47. Méry JP, Delahousse M, Nochy D. Amyloidosis and infection due to human

- immunodeficiency virus. *Clin Infect Dis* 1993; 16:733-734
48. Nochy D, Glotz D, Dosquet P, Pruna A, Lemoine R, Guettier C, Weiss L, Hinglais N, Idatte JM, Méry JP. Renal lesions associated with human immunodeficiency virus infection: North American vs, European experience, *Adv Nephrol Necker Hosp* 1993; 22:269-286
 49. Szczech LA, Gupta SK, Habash R, Guasch A, Kalayjian R, Appel R, Fields R, Fields TA, Svetkey LP, Flanagan KH, Klotman PE, Winston JA. The clinical epidemiology and course of the spectrum of renal diseases associated with HIV-infection. *Kidney Int* 2004; 66:2245-1152.
 50. Kamar N, Rostaing L, Alric L. Treatment of hepatitis C-virus-related glomerulonephritis. *Kidney Int* 2006;69(3):436-9
 51. Masia-Canuto M, Bernal-Morell E, Gutierrez-Rodero F. Lipid alterations and cardiovascular risk associated with antiretroviral therapy. *Enferm Infecc Microbiol Clin* 2006;24(10):637-48.
 52. Szczech LA, Gupta SK, Habash R, Guasch A, Kalayjian R, Appel R, et al. The clinical epidemiology and course of the spectrum of renal diseases associated with HIV infection. *Kidney Int* 2004;66(3):1145-52.
 53. Wyatt CM, Morgello S, Katz-Malamed R, Wei C, Klotman ME, Klotman PE, et al. The spectrum of kidney disease in patients with AIDS in the era of antiretroviral therapy. *Kidney Int* 2009;75:428-34
 54. Schmieder RE, Mann JF, Schumacher H, Gao P, Mancia G, Weber MA, et al.; ONTARGET Investigators. Changes in albuminuria predict mortality and morbidity in patients with vascular disease. *J Am Soc Nephrol* 2011;22(7):1353-64
 55. Mocroft A, Ryom L, Reiss P, Furrer H, D'Arminio Monforte A, Gatell J, de Wit S, Beniowski M, Lundgren JD, Kirk O for EuroSIDA in EuroCOORD. A comparison of estimated glomerular filtration rates using Cockcroft-Gault and the Chronic Kidney Disease Epidemiology Collaboration estimating equations in HIV infection. *Hiv Med*. 2014 Mar;15(3):144-152
 56. Levey AS, Bosch JP, Lewis JB, Greene T, Rogers N, Roth D. A more accurate method to estimate glomerular filtration rate from serum creatinine: a new prediction equation. Modification of Diet in Renal Disease Study Group. *Ann Intern Med*. 1999 Mar 16;130(6):461-70
 57. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T, Coresh J; CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration). A new equation to estimate glomerular filtration rate. *Ann Intern Med*. 2009 May 5;150(9):604-12
 58. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron*. 1976;16(1):31-41
 59. Stevens LA, Nolin TD, Richardson MM, Feldman HM, Lewis JB, Rodby R, Townsend R, Okparavero A, Zhang YL, Schmid CH, Levey AS; Chronic Kidney Disease Epidemiology Collaboration. Comparison of drug dosing recommendations based on measured GFR and kidney function estimating equations. *Am J Kidney Dis*. 2009 Jul;54(1):33-42
 60. European AIDS Clinical Society guidelines 2013. Available at: <http://www.eacsociety.org/Guidelines.aspx>
 61. Gupta SK, Mamlin BW, Johnson CS, Dollins MD, Topf JM, Dubé MP. Prevalence of proteinuria and the development of chronic kidney disease in HIV-infected patients. *Clin Nephrol*. 2004 Jan;61(1):1-6
 62. Szczech LA, Gange SJ, van der Horst C, Bartlett JA, Young M, Cohen MH, Anastos K, Klassen PS, Svetkey LP. Predictors of proteinuria and renal failure among women with HIV infection. *Kidney Int*. 2002 Jan;61(1):195-202
 63. Jotwani V, Li Y, Grunfeld C, Choi AI, Shlipak MG. Risk factors for ESRD in HIV-infected individuals: Traditional and HIV-related factors. *Am J Kidney Dis*. 2012 May;59(5):628-35
 64. Itoh Y, Ichihara K, Kishi K, Hosogaya S, Yamada T. Preparation of highly purified monomeric human serum albumin as secondary reference material for standardization of urinary albumin immunoassays. *Clin Chim Acta*. 2012 Jan 18;413(1-2):175-81
 65. Miller WG, Bruns DE, Hortin GL, Sandberg S, Aakre KM, McQueen MJ, Itoh Y, Lieske JC, Seccombe DW, Jones G, Bunk DM, Curhan GC, Narva AS; National Kidney Disease Education Program-IFCC Working group on Standardization of Albumin in Urine. Current issues in measurement and reporting of urinary albumin excretion.
 66. Siedner MJ, Atta MG, Lucas GM, Perazella MA, Fine DM. Poor validity of urine dipstick as a screening tool for proteinuria in HIV-positive patients. *J*

- Acquir Immune Defic Syndr. 2008 Feb 1;47(2):261-3
67. Smith ER, Cai MM, McMahon LP, Wright DA, Holt SG. The value of simultaneous measurements of urinary albumin and total protein in proteinuric patients. *Nephrol Dial Transplant*. 2012 Apr;27(4):1534-41
 68. Kumar MSA, Sierka DR, Damask AM, Fyfe B, Mcalack RF, Heifets M, Moritz MJ, Alvarez D, Kumar A. Safety and success of kidney transplantation and concomitant immunosuppression in HIV-positive patients. *Kidney Int*. 2005 Apr;67(4):1622-9
 69. Ahuja TS, Grady J, Khan S. Changing trends in the survival of dialysis patients with immunodeficiency virus in the United States. *J Am Soc Nephrol*. 2002 Jul;13(7):1889-93
 70. Ortiz C, Meneses R, Jaffe D, Fernandez JA, Perez G, Bourgoignie JJ. Outcome of patients with human immunodeficiency virus on maintenance hemodialysis. *Kidney Int*. 1988 Aug;34(2):248-53
 71. Trullás JC, Cofan F, Barril G, Martínéz-Castelao A, Jofre R, Rivera M, Martínéz-Ara J, Ros S, Perez I, Moreno A, Miró JM; Spanish HIV Infection in Dialysis Study Group. Outcome and prognostic factors in HIV-1-infected patients in the cART era: a GESIDA/SEN cohort study. *J Acquir Immune Defic Syndr*. 2011 Aug 1;57(4):276-83
 72. Gupta SK, Eustace JA, Boydston II, Ahuja TS, Rodriguez RA, Tashima KT, Roland M, Franceschini N, Palella FJ, Lennox JL, Klotman PE, Nachman SA, Hall SD, Szczech LA. Guidelines for the management of chronic kidney disease in HIV-infected patients: recommendations of the HIV Medicine Association of the Infectious Diseases Society of America. *Clin Infect Dis*. 2005 Jun 1;40(11):1559-85
 73. Wyatt CM. The kidney in HIV infection: beyond HIV-associated nephropathy. *Top Antivir Med*. 2012 Aug-Sep;20(3):106-10
 74. <http://www.pbs.org/wgbh/aso/databank/entries/dm54ki.html>
 75. <https://www.kidney.org/transplantation/transaction/Milestones-Organ-Transplantation>
 76. Spital A. Should all human immunodeficiency virus-infected patients with end-stage renal disease be excluded from transplantation? The view of U.S. transplant center. *Transplantation*. 1998 May 15;65(9):1178-91
 77. Chin-Hong P, Beatty G, Stock P. Perspectives on Liver and Kidney Transplantation in the HIV-infected Patient. *Infect Dis Clin North Am*. 2013 June; 27(2):459-71
 78. Sawinski D, Wyatt CM, Casagrande L, Myoung P, Bijan I, Akalin E, Schröppel B, DeBoccardo G, Sehgal V, Dinavahi R, Lerner S, Ames S, Bromberg J, Huprikar S, Keller M, Murphy B. Factors associated with failure to list HIV-positive kidney transplant candidates. *Am J Transplant*. 2009 Jun;9(6):1467-71
 79. Norman SP, Kommareddi M, Kaul DR. Update on Kidney transplantation in HIV-infected recipients. *AIDS rev*. 2012;14:195-207
 80. <http://www.usrds.org/atlas12.aspx>
 81. Rodrigue JR, Paek MJ, Egbuna O, Waterman AD, Pavlakakis M, Mandelbrot DA. Willingness to Pursue Live Donor Kidney Transplantation Among Wait-listed Patients infected with Human Immunodeficiency virus (HIV): A preliminary investigation. *Transplantation*. 2013 March 27;95(6):787-90
 82. Stutterheim SE, Bos AE, Pryor JB, Brands R, Liebrechts M, Schaalma HP. Psychological and social correlated of HIV status disclosure: the significance of stigma visibility. *AIDS Educ Prev*. 2011 Aug;23(4):382-92
 83. Kalichman SC, DiMarco M, Austin J, Luke W, DiFonzo K. Stress, social support, and HIV-status disclosure to family and friends among HIV-positive men and women. *J Behav Med*. 2003 Aug;26(4):315-32
 84. Rizzardi GP, Harari Alexandre, Capiluppi B, Tambussi G, Ellefsen K, Ciuffreda D, Champagne P, Bart PA, Chave JP, Lazzarin A, Pantaleo G. Treatment of primary HIV-1 infection with cyclosporin A coupled with highly active antiretroviral therapy. *J Clin Invest*. 2002 Mar 1; 109(5): 681-688
 85. Connolly N, Riddler S, Rinaldo C. Proinflammatory cytokines in HIV disease - a review and rationale for new therapeutic approaches. *AIDS Rev*. 2005;7:168-80
 86. Brechley J, Price D, Schacker T. et al. Microbial translocation is a cause of systemic immune activation in chronic HIV infection. *Nat Med*. 2006; 12:1365-1371
 87. Stoiber H, Soederholm A, Wilflingseder D, Gusenbauer S, Hildgartner A, Dierich M. Complement and antibodies: A dangerous liaison in HIV infection? *Vaccine*. 2008;26(8):179-85

88. Wiegers K, Kräusslich HG. Differential dependence of the infectivity of HIV-1 group O isolates on the cellular protein cyclophilin A. *Virology*. 2002 Mar 15;294(2):289-95
89. Streblov DN, Kitabwalla M, Malkowsky M, Pauza CD. Cyclophilin A modulates processing of human immunodeficiency virus type 1 p55Gag: mechanism for antiviral effects of cyclosporin A. *Virology*. 1998 Jun 5;245(2):197-202
90. Briggs CJ, Tözser J, Oroszlan S. Effect of cyclosporin A on the replication cycle of human immunodeficiency virus type 1 derived from H9 and Molt-4 producer cells. *J Gen Virol*. 1996 Dec; 77:2963-7
91. Briggs CJ, Ott DE, Coren LV, Oroszlan S, Tözser J. Comparison of the effect of FK506 and cyclosporin A on virus production in H9 cells chronically and newly infected by HIV-1. *Arch Virol*. 1999;144(11):2151-50
92. Heredia A, Amoroso A, Davis C, Le N, Reardon E, Dominique JK, Klingebiel E, Gallo RC, Redfield RR. Rapamycin causes down-regulation of CCR5 and accumulation of anti-HIV beta-chemokines: an approach to suppress R5 strains of HIV-1. *Proc Natl Acad Sci U S A*. 2003 Sep 2;100(18):10411-6
93. Tzakis AG, Cooper MH, Dummer JS, Ragni M, Ward JW, Starzl TE. Transplantation in HIV+ patients. *Transplantation*. 1990 Feb;49(2):354-8
94. Erice A, Rhame FS, Heussner RC, Dunn DL, Balfour HH Jr. Human immunodeficiency virus infection in patients with solid-organ transplants: report of five cases and review. *Rev infect Dis*. 1991 Jul-Aug;13(4):537-47
95. Bouscarat F, Samuel D, Simon D, Debat P, Bismuth H, Saimot AG. An observational study of 11 French liver transplant recipients infected with human immunodeficiency virus type 1. *Clin Infect Dis*. 1994 Nov;19(5):854-9
96. Stock P, Roland M, Carlson L, et al. Kidney and liver transplantation in human immunodeficiency virus-infected patients: a pilot safety and efficacy study. *Transplantation*. 2007;84:563-71
97. UNITED STATES DEPARTMENT OF HEALTH AND HUMAN SERVICES: ANNUAL DATA REPORT. Atlas of the end-stage renal disease in the United States. United States Renal Data System, 2003. pp.412-442
98. Qiu J, Terasaki PI, Waki K, Cai J, Gjertson DW. HIV-positive renal recipients can achieve survival rates similar to those of HIV-negative patients. *Transplantation* 2006;81:1658-1661
99. <http://optn.transplant.hrsa.gov/>
100. Roland ME, Barin B, Carlson L, Frassetto LA, Terrault NA, Hirose R, Freise CE, Benet LZ, Ascher NL, Roberts JP, Murphy B, Keller MJ, Olthoff KM, Blumberg EA, Brayman KL, Bartlett ST, Davis CE, McCune JM, Bredt BM, Stablein DM, Stock P.G. HIV-infected liver and kidney transplant recipients: 1- and 3-year outcomes. *Am J transplant*. 2008;8:355-65
101. Basic-Jukic N, Katalinic L, Bubic-Filipi L, Kes P, Begovac J, Pasini E, Pasini J. Kidney transplantation in a HIV infected Patient; A case report. *Bantao J*. 2012;10(2):87-89
102. Health Quality Ontario. Kidney and liver organ transplantation in persons with human immunodeficiency virus: An Evidence-Based Analysis. *Ont Health Technol Assess Ser*. 2010;10(4):1-56
103. Marfo K, Greenstein S. Antiretroviral and immunosuppressive drug-drug interactions in human immunodeficiency virus-infected liver and kidney transplant recipients. *Transplant Proc*. 2009 Nov;41(9):3796-9
104. Frassetto LA, Floren LC, Barin B, Browne M, Wolfe AR, Roland ME, Stock PG, Carlson L, Christians U, Benet LZ. Changes in clearance, volume and bioavailability of immunosuppressant when given with HAART in HIV-1 infected liver and kidney transplant patients. *Biopharm Drug Dispos*. 2013 November; 34(8):442-451
105. Saeki T, Ueda K, Tanigawara Y, Hori R, Komano T. Human P-glycoprotein transports cyclosporin A and FK506. *J Biol Chem*. 1993 Mar;268(9):6077-80
106. Christians U, Jacobsen W, Benet LZ, Lampen A. Mechanisms of clinically relevant drug interactions associated with tacrolimus. *Clin Pharmacokinet*. 2002;41(11):813-51
107. Jain AK, Venkataramanan R, Fridell JA, Gadowski M, Shaw LM, Ragni M, Korecka M, Fung J. Nelfinavir, a protease inhibitor, increases sirolimus levels in a liver transplantation patient: a case report. *Liver Transpl*. 2002 Sep;8(9):838-40
108. Chapuis AG, Paolo Rizzardi G, D'Agostino C, Attinger A, Knabenhans C, Fleury S, Acha-Orbea H, Pantaleo G. Effects of mycophenolic acid on human immunodeficiency virus infection in vitro and in vivo. *Nat Med*. 2000 Jul6(7):762-8
109. Christiaans M, van Duijnhoven E, Beysens T, Undre N, Schäfer A, van Hooff J. Effect of breakfast on the oral bioavailability of

- tacrolimus and changes in pharmacokinetics at different times posttransplant in renal transplant recipients. *Transplant Proc.* 1998 Jun;30(4):1271-3
110. 2008 annual report of the U.S. Organ Procurement and Transplantation Network and the Scientific registry of Transplant Recipients: Transplant data 1998-2007. U.S. Department of Health and Human Services, Health Resources and Services Administration, Healthcare Systems Bureau, Division of Transplantation, Rockville, MD.
 111. Stock PG, Barin B, Murphy B, Hanto D, Diego JM, Light J, Davis C, Blumberg E, Simon D, Subramanian A, Millis JM, Lyon GM, Brayman K, Slakey D, Shapiro R, Melancon J, Jacobson JM, Stosor V, Olson JL, Stablein DM, Roland ME. Outcomes of kidney transplantation in HIV-infected recipients. *N Eng J Med.* 2010 Nov 18;363(21):2004-14
 112. Fischereder M, Luckow B, Hocher B, Wütrich RP, Rothenpieler U, Schneeberger H, Panzer U, Stahl RA, Hauser IA, Budde K, Neumayer H, Krämer BK, Land W, Schlöndorff D. CC chemokine receptor 5 and renal-transplant survival. *Lancet.* 2001 Jun 2;357(9270):1758-61
 113. Heidenhain C, Puhl G, Moench C, Lautem A, Neuhaus P. Chemokine receptor 5delta32 mutation reduces the risk of acute rejection in liver transplantation. *Ann Transplant.* 2009 Jul-Sep;14(3):36-44
 114. Resher R, Luger SM, Hexner EO, Loren AW, Frey NV, Nasta SD, Goldstein SC, Stadtmauer EA, Smith J, Bailey S, Mich R, Heitjan DF, Emerson SG, Hoxie JA, Conderheide RH, Porter DL. Blockade of lymphocyte chemotaxis in visceral graft-versus-host disease. *N Eng J Med.* 2012 Jul 12;367(2):135-45
 115. Pascual J, Quereda C, Zamora J, Hernández D; Spanish Group for Evidence-Based Medicine in Renal Transplantation. Steroid withdrawal in renal transplant patients on triple therapy with a calcineurin inhibitor and mycophenolate mofetil: a meta-analysis of randomized, controlled trials. *Transplantation.* 2004 Nov 27;78(10):1548-56
 116. Knight SR, Morris PJ. Steroid avoidance or withdrawal after renal transplantation increases the risk of acute rejection but decreases cardiovascular risk. A meta-analysis. *Transplantation.* 2010 Jan 15;89(1):1-14
 117. Zhang X, Huang H, Han S, Fu S, Wang L. Is it safe to withdraw steroids within seven days of renal transplantation? *Clin Transplant.* 2013 Jan-Feb;27(1):1-8
 118. Muthukuar T, Afaneh C, Ding R, Tsapepas D, Lubetzky M, Jacobs S, Lee J, Sharma V, Lee J, Dadhania D, Hartono C, McDermott J, Aull M, Leeser D, Kapur S, Serur D, Suthanthiran M. HIV-infected kidney graft recipients managed with an early corticosteroid withdrawal protocol: clinical outcomes and messenger RNA profiles. *Transplantation* 2013 Mar 15;95(5):711-20
 119. Soriano V, Martin-Carbonero L, Maida I, Garcia-Samaniego J, Nuñez M. New paradigms in the management of HIV and hepatitis C coinfection. *Curr Opin Infect Dis.* 2005 Dec;18(6):550-60
 120. Norris S, Taylor C, Muiesan P, Portmann BC, Knisely AS, Bowles M, Rela M, Heaton N, O'Grady JG. Outcomes of liver transplantation in HIV-infected individuals: the impact of HCV and HBV infection. *Liver Transpl.* 2004 Oct;10(10):1271-8
 121. Ragni MV, Eghtesad B, Schlesinger KW, Dvorchik I, Fung JJ. Pretransplant survival is shorter in HIV-positive than HIV-negative subjects with end-stage liver disease. *Liver Transpl.* 2005 Nov;11(11):1425-30
 122. Luetkemeyer AF, Havlir DV, Currier JS. Complications of HIV disease and antiretroviral therapy. *Top Antivir Med.* 2012 Jun-Jul;20(2):48-60

Tables

1. Richard J. Johnson, John Feehally, Jurgen Floege (2015), p. 683. Comprehensive clinical nephrology 5th edition, Philadelphia, Elsevier Saunders
2. Richard J. Johnson, John Feehally, Jurgen Floege (2015), p. 685. Comprehensive clinical nephrology 5th edition, Philadelphia, Elsevier Saunders
3. Richard J. Johnson, John Feehally, Jurgen Floege (2015), p. 685. Comprehensive clinical nephrology 5th edition, Philadelphia, Elsevier Saunders
4. Stock PG, Roland M. Evolving clinical strategies for transplantation in the HIV-positive recipient. Transplantation. 2007;84:563-71

Biography

Emma Eliasson was born in Stockholm, Sweden in 1988. She lived there up until she was 21 years old and moved to Croatia to study medicine. After her first year she had a short internship in Addis Cardiac Hospital in Addis Abbeba, Ethiopia. During the summers she worked with people with psychiatric disabilities, children with neurological disabilities and as a personal aid. She worked as a student demonstrator in the course propedeutics on the nephrology department under the mentorship of prof. dr. sc. Bašić-Jukić and in 2014 they published an article on the outcome of renal transplantation in patients with HIV treated at KBC Zagreb together.